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PATENT APPLICATION

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For: Building Elements and Building Element Assemblies Formed Therewith

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

(0001) This application is a continuation-in-part of prior U.S. Patent Application Serial No. 09/774,604 filed February 1, 2001, which is a continuation-in-part of prior U.S. Patent Application Serial No. 09/472,423 filed December 27, 1999, the entire disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention:

(0002) The present invention relates to building elements such as columns and beams and, more particularly, to metal building elements having side flanges extending from webs formed with constrictions and to building element assemblies formed therewith.

Brief Discussion of the Related Art:

(0003) Metal sheets can be formed via a cold folding process into various irregular shapes or profiles. Cold folding of metal sheets typically involves two-dimensional deformation of the metal sheets. The folding that can be effected from plastic deformation of metal sheets in a cold folding process is preferable to other currently existing metal shaping or forming processes, such as a sealing press or a deep drawing press, since it allows a greater variety of shapes or profiles to be obtained, including a great variety of irregular shapes or profiles. A variety of shapes or profiles can be successfully obtained with metal sheets via a cold folding process where

b/s > 5, with s being the thickness of the sheet and b being the length of the sheet.

(0004) Metal sheets have been cold folded into shapes or profiles of great variety and high quality using sheet folding machines, as has been accomplished in the construction and steel industries, in the shipbuilding industry, in small and medium-sized industries and even in handicraft workshops. Considering this diversity, the publication by Siebel and Beisswanger of their studies of pressing, and the calculations performed by the Forschungsgesellschaft Blechverarbeitung (Society for Research on Sheet Production), it seems appropriate to view cold folding not just as a process but also as the sheet folding machine's contribution to the demand for specific profiles.

(0005) In the area of construction, building elements made from shaped metal sheets have been assembled to form structural beams and columns for use as permanent supports in buildings or similar structures. Building elements having various irregular shapes or profiles have been used, including those having side flanges extending from webs formed with constrictions as represented by U.S. Patents Nos. 2,082,792 to Dean, 2,121,037 to Kotrbaty, 2,125,690 to Ragsdale et al, 2,508,032 to Kennedy, 2,975,874 to Pagan, 3,280,530 to Rothenback, 3,359,022 to Russell, 4,109,440 to Bill, 5,464,302 to Menchetti, 5,771,653 to Dolati et al, and 5,970,678 to Pellock et al. The constrictions extend from the webs about the same distance as the side flanges (Dean, Kotrbaty and Kennedy), about half the distance of the side flanges (Ragsdale et al and Menchetti), considerably less than one-third the distance of the side flanges (Pagan, Pellock et al and Dolati et al) and greater than the distance of the

side flanges (Bill). The constrictions of prior building elements do not have a width about one third the overall width of the building elements and, in many of the prior building elements, the constrictions are undesirably continuously curving and/or undesirably do not have rounded or curved corners. Furthermore, the height of the constrictions is typically considerably large in proportion to the overall height of the building elements, as represented by Dean, Ragsdale et al, Kennedy, Bill and Menchetti, or is considerably small in proportion to the overall height of the building elements, as represented by Pagan. While some prior building elements have a constriction centered between the side flanges, it has not been recognized to advantageously locate the constriction a distance from one of the side flanges that is about one third the overall height of the building element. It has also not been recognized to assemble two building elements in web-to-web relation to form a building element assembly, particularly useful as a beam, in which the constrictions of the building elements are each spaced from a bottom side flange of the corresponding building element a distance of about one third the overall height of the building element for enhanced tensile strength. Prior building elements having constrictions do not recognize an optimum angle for the arms of the constrictions in relation to a constriction axis.

(0006) Components made from shaped metal sheets have been proposed as supports for purposes other than buildings or similar structures. U.S. Patent No. 3,977,149 to Haynes et al, for example, illustrates shaped metal components assembled as a form for poured concrete. U.S. Patent No. 4,002,000 to Howard et al

discloses shaped metal components assembled to form beams used in storage or pallet racks. The components of Haynes et al and Howard et al include constrictions formed in the webs thereof; however, the components are not designed to withstand the same loads as structural beams or columns used in buildings or similar structures. The constrictions disclosed by Haynes et al extend from the webs about the same distance as the side flanges and do not have rounded corners. The constriction disclosed by Howard et al forms the entire web, and the height of the constriction is considerably large in proportion to the overall height of the component.

(0007) Conventional shaped metal building elements possess numerous disadvantages including the inability to be used individually and/or in combination as beams and/or columns, the need for extraneous components or parts in order to assemble the building elements to form structural members such as beams and columns, the need to fabricate an individual building element of multiple parts and not integrally, unitarily or monolithically as a single part, the need for additional components or parts to impart stability and/or rigidity to the building elements, the inability of the building elements to resist high compression, traction and tension, the constrictions being either too large or too small to achieve optimum strength and rigidity, the constrictions not being optimally located along the height of the building elements, the arms of the constrictions defining a less than optimal angle with the constriction axis, the constrictions lacking a desirable combination of linear and curved segments, the building elements not being lightweight, and complexity in manufacture and assembly resulting in high construction costs.

OBJECTS AND SUMMARY OF THE INVENTION

(0008) Accordingly, it is a primary object of the present invention to overcome the aforementioned disadvantages of prior art shaped metal building elements.

(0009) Another object of the present invention is to provide shaped metal building elements usable individually as beams and/or columns or in combination to form beam and/or column assemblies.

(0010) An additional object of the present invention is to provide a shaped metal building element having a geometric profile presenting increased resistance to compression, traction and tension.

(0011) A further object of the present invention is to increase the loading capacity of a standard structural steel member by forming a constriction in the web of the standard structural steel member.

(0012) The present invention also has as an object to provide a plurality of shaped metal building elements capable of being assembled in various ways to form various beam and/or column assemblies.

(0013) It is also an object of the present invention to increase the loading capacity of a shaped metal building element by optimally locating a constriction of the

building element between its side flanges.

(0014) Yet another object of the present invention is to utilize a cold folding process to form a shaped metal building element having side flanges extending from a web formed with at least one constriction having rounded corners.

(0015) Still a further object of the present invention is to increase the loading capacity of a beam assembly having two building elements assembled in web-to-web relation with each building element having a constriction located an optimal distance from a bottom side flange of the building element.

(0016) The aforesaid objects are achieved individually and in combination, and it is not intended that the present invention be construed as requiring two or more of the objects to be combined.

(0017) Some of the advantages of the present invention are that the building elements have greater rigidity and stability, the building elements can be of any desired length, the building elements can be manufactured automatically such as with high capacity shaping rods, an individual building element may be formed integrally, unitarily or monolithically as a single component without the need for multiple parts, the building elements have an optimum resistance-to-weight ratio, the building elements are lighter than conventional shaped metal building elements, the building elements and the

building element assemblies formed therewith comply with current anti-seismic and structural steel regulations, displacements caused by seismic loads are limited or controlled due to the moment of inertia characteristics of the building elements, the number, shape, size and location of the constrictions can be varied in proportion with the overall height and width of the building elements and in accordance with the particular architectural design and structural loading requirements for buildings or other similar structures in which the building elements are used, the building elements can be of desired gauge or thickness, plural building elements can be assembled in a manner to accommodate construction components such as electrical wiring or cables and/or plumbing, the building elements can be shaped so as to provide a mechanical joint or connector facilitating connection with other building elements and/or with other structural members such as wall, floor, ceiling and window structures, the building elements can be reasonably priced, construction waste is minimized and construction costs are reduced.

(0018) These and other objects, advantages and benefits are realized with the present invention as generally characterized in a building element including a profile of substantially uniform cross-section extending lengthwise between first and second ends. The profile is defined by a web, a pair of side flanges extending perpendicular to the web and outer corners joining the side flanges, respectively, to the web. The web includes at least one constriction extending in the same direction as the side flanges, a pair of planar segments disposed on opposite sides of the constriction, and inner corners joining the planar segments, respectively, to the constriction. The constriction

includes arms extending angularly inwardly from the inner corners, respectively, to a curved base having an apex contained in a plane. The planar segments have outer surfaces, respectively, contained in a plane parallel to the plane of the apex. The side flanges extend from the outer corners, respectively, to tips, respectively, that are contained in a plane parallel to the plane of the apex. The building element has an overall width between the plane of the planar segments and the plane of the tips. The constriction has a width between the plane of the planar segments and the plane of the apex, and the width of the constriction is about one-third the overall width of the building element.

(0019) The constriction may be disposed centrally or non-centrally along the height of the building element. The arms of the constriction preferably define an angle of about 70 °. The arms of the constriction are joined to the inner corners at junctions, and the constriction has a height between the junctions that is preferably no greater than one-fourth the overall height of the building element. The overall width of the building element is preferably one-half the overall height or one-fourth the overall height. The side flanges include planar portions extending from the outer corners toward the tips and the tips may be coplanar with the planar portions of the side flanges. The tips may comprise end flanges angled outwardly or inwardly with respect to the planar portions of the side flanges, and the end flanges may be angled inwardly toward one another perpendicular to the planar portions of the side flanges. The end flanges can be of any suitable length. The inner and outer corners are preferably

curved, and the end flanges may be joined to planar portions of the side flanges by outside corners which are also preferably curved. The constriction is bisected by a constriction axis at its apex and is symmetrical about its constriction axis. The side flanges may be formed with outward and/or inward protrusions.

(0020) The present invention is also generally characterized in a building element including a profile of substantially uniform cross-section extending lengthwise between first and second ends. The profile is defined by a web, a pair of side flanges extending perpendicular to the web and outer corners joining the side flanges, respectively, to the web. The web includes a constriction extending in the same direction as the side flanges, a pair of planar segments, respectively, disposed on opposite sides of the constriction, and inner corners joining the planar segments to the constriction. The planar segments have outer surfaces, respectively, contained in a plane and the constriction is bisected by a constriction axis perpendicular to the plane of the planar segments. The constriction includes a pair of arms extending angularly inwardly toward one another from the inner corners, respectively, to a curved based having an apex. The side flanges extend from the outer corners, respectively, to tips, respectively, that are contained in a plane parallel to the plane of the planar segments. The side flanges have outer surfaces, respectively, disposed in parallel planes perpendicular to the plane of the planar segments, and the building element has an overall height between the parallel planes of the side flanges. The building element has an overall width between the plane of the planar segments and the plane of the tips. The constriction axis is located along the overall height of the building element a distance of one-third the

overall height from one of the planes of the side flanges and a distance of two-thirds the overall height from the other of the planes of the side flanges.

(0021) The overall width is preferably one-fourth the overall height of the building element. The constriction has a width between a plane containing the apex and the plane of the planar segments, and the width of the constriction is preferably one-third the overall width of the building element. The arms of the constriction are joined to the inner corners at junctions, and the constriction has a height between the junctions that is preferably no greater than one- fourth the overall height of the building element. The arms of the constriction preferably define an angle of 70 °, and the height of the constriction is preferably about 4.2 cm. The tips may include end flanges angled inwardly or outwardly from planar portions of the side flanges, respectively, and the end flanges may be parallel to the planar segments. The inner and outer corners are preferably curved, and the end flanges may be joined to the planar portions of the side flanges at outside corners which are also preferably curved. The side flanges may be formed with inward and/or outward protrusions.

(0022) The present invention is also generally characterized in a building element comprising a profile of generally uniform cross-section extending between first and second ends and having a web and a pair of side flanges extending perpendicular to the web. The web includes a constriction extending in the same direction as the side flanges and web segments on opposite sides of the constriction. The constriction has a

pair of arms extending linearly from the web segments, which may be planar, to a curved base. The constriction is bisected by a constriction axis that is parallel to the side flanges and each arm extends angularly from its corresponding web segment at an angle of or about 35° to the constriction axis.

(0023) Other objects and advantages of the present invention will become apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings, wherein like parts in each of the several figures are identified by the same reference characters.

BRIEF DESCRIPTION OF THE DRAWINGS

(0024) Fig. 1 is a broken perspective view of a building element according to the present invention.

(0025) Fig. 2 is an end view of the building element of Fig. 1.

(0026) Fig. 3A is an end view of a metal sheet capable of being formed into the building element of Fig. 1.

(0027) Fig. 3B is an end view of the metal sheet formed to define a web and side flanges extending from the web.

(0028) Fig. 3C is an end view of the metal sheet formed to define a constriction in

the web.

(0029) Fig. 4A is an end view of a conventional structural steel member capable of being formed into the building element of Fig. 1.

(0030) Fig. 4B is an end view of the conventional structural steel member formed to define a constriction in the web thereof.

(0031) Fig. 5 is a broken, sectional top view illustrating use of the building element of Fig. 1 as a column with a wall structure disposed between the side flanges of the building element.

(0032) Fig. 6 is a broken, sectional end view illustrating use of the building element of Fig. 1 as a beam with a floor structure disposed between the side flanges of the building element.

(0033) Fig. 7 is a sectional view illustrating assembly of two of the building elements of Fig. 1 in web-to-web relation to form a building element assembly usable as a column or beam assembly.

(0034) Fig. 8 is a sectional view illustrating assembly of two of the building elements of Fig. 1 in tip-to-tip relation to form an alternative building element assembly

usable as a column or beam assembly.

(0035) Fig. 9 is a sectional view illustrating assembly of three of the building elements of Fig. 1 to form another building element assembly usable as a column or beam assembly.

(0036) Fig. 10 is a sectional view illustrating assembly of four of the building elements of Fig. 1 to form a modified building element assembly usable as a column or beam assembly.

(0037) Fig. 11 is a sectional view illustrating an alternative assembly of four of the building elements of Fig. 1 to form yet another building element assembly usable as a column or beam assembly.

(0038) Fig. 12 is a sectional view illustrating assembly of three, four or five of the building elements of Fig. 1 to form further alternative building element assemblies usable as column or beam assemblies.

(0039) Fig. 13 is an end view of an alternative building element according to the present invention having two constrictions.

(0040) Fig. 14 is an end view of another alternative building element according to

the present invention having three constrictions.

(0041) Fig. 15 is an end view of a further alternative building element according to the present invention having four constrictions.

(0042) Fig. 16 is an end view of an additional alternative building element according to the present invention having outwardly extending protrusions in the side flanges thereof.

(0043) Fig. 17 is an end view of yet another alternative building element according to the present invention having inwardly extending protrusions in the side flanges thereof.

(0044) Fig. 18 is an end view of still another alternative building element according to the present invention having inwardly protruding tips.

(0045) Fig. 19 is an end view of still a further alternative building element according to the present invention having outwardly protruding tips.

(0046) Fig. 20 is a sectional view illustrating assembly of two of the building elements of Fig. 18 in tip-to-tip relation to form an additional building element assembly usable as a column or beam assembly.

(0047) Fig. 21 is a broken top view illustrating assembly of two of the building elements of Fig. 19 in web-to-web relation to form still another building element assembly used as a column assembly for four wall structures.

(0048) Fig. 22 is a sectional view illustrating another alternative building element according to the present invention having outwardly extending protrusions and inwardly protruding tips assembled in tip-to-tip relation with a like building element to form a further building element assembly usable as a column or beam assembly.

(0049) Fig. 23 is a sectional view of an additional alternative building element showing two of the additional alternative building elements assembled in web-to-web relation to form a building element assembly.

(0050) Fig. 24 is a sectional view of a further additional building element showing two of the further additional building elements assembled in web-to-web relation to form a building element assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(0051) A building element 10 according to the present invention is illustrated in Figs. 1 and 2. The building element 10 is made of metal and has a generally E-shaped profile in end and cross-sectional view. The profile is uniform or substantially uniform in cross-section along a length L of the building element defined between first and second

ends 12 and 14. The profile has a uniform or substantially uniform thickness T and is defined by a web 16, first and second side flanges 18 and 20 extending perpendicular to web 16 in the same direction, first and second outer corners 22 and 24 joining the first and second side flanges, respectively, to the web 16, and at least one constriction 26 in web 16 extending in the same direction as the first and second side flanges. The side flanges 18, 20 are bent or folded at a right angle to web 16 and extend from outer corners 22 and 24, respectively, to the left in Figs. 1 and 2, to tips 29 and 31 of the side flanges terminating at first and second side edges 28 and 30, respectively, of the tips. The side flanges 18 and 20 include planar portions, respectively, parallel to one another and extending from outer corners 22 and 24, respectively, the same distance. The outer corners 22 and 24 are curved, arcuate, radiused or rounded and extend between first and second planar segments 32 and 34, respectively, of web 16 and the planar portions of the side flanges 18 and 20, respectively. In the case of building element 10, the side flanges 18 and 20 are planar between outer corners 22 and 24 and side edges 28 and 30, respectively, so that the planar portions include the tips of the side flanges, respectively, and extend to the side edges 28 and 30. The side edges 28 and 30 terminate at a common plane that is parallel to the planar segments 32 and 34 of web 16, and the tips are thusly contained in this plane. Outer surfaces of the side flanges 18 and 20, respectively, are contained in parallel planes, as seen by the outer surfaces of the planar portions of the side flanges 18 and 20 being contained in parallel planes.

(0052) The web 16 includes constriction 26, planar segments 32 and 34 on opposite sides of constriction 26 and first and second inner corners 36 and 38

extending between constriction 26 and the first and second planar segments 32 and 34, respectively. The planar segments 32 and 34 have outer surfaces, respectively, disposed in a plane parallel to the plane of the tips 29 and 31 and perpendicular to the planes of side flanges 18 and 20. The constriction 26 may be centrally located in web 16 and, therefore, may be centrally located between the side flanges 18 and 20 as shown for constriction 26. The constriction 26 has a generally V-shaped configuration with first and second arms 40 and 42 extending angularly outwardly from a base 44 to the first and second inner corners 36 and 38, respectively. The base 44 is curved, arcuate, radiused or rounded, and the apex thereof is coincident with a constriction axis X which is centrally located between the side flanges 18 and 20 in the case of building element 10. The constriction axis X bisects the constriction 26 at its apex and is perpendicular to the plane of the planar segments 32 and 34. The constriction 26 is symmetrical about the constriction axis X. The entire building element 10 is also symmetrical about the constriction axis X where the constriction axis X is centrally located between the side flanges 18 and 20. The apex of the constriction 26 is contained in a plane parallel to the plane of the planar segments 32 and 34 and the plane of the tips 29 and 31. The inner corners 36 and 38 are curved, arcuate, radiused or rounded between planar segments 32 and 34 and arms 40 and 42, respectively. Arms 40 and 42 are straight or linear between base 44 and inner corners 36 and 38, respectively.

(0053) The profile defined by building element 10 has an overall height H between the planes of the side flanges 18 and 20, respectively, as shown in Fig. 2. In

the case of building element 10, the overall height H is defined between parallel planes containing the outer surfaces of the planar portions of side flanges 18 and 20, respectively, and the constriction axis X is centrally located along the overall height. The building element 10 has an overall width W between the plane of the tips 29 and 31 and the plane of the planar segments 32 and 34. The overall width W for building element 10 is depicted in Fig. 2 between the plane of side edges 28 and 30 and the plane containing the outer surfaces of planar segments 32 and 34. The constriction 26 extends the entire length L of the building element 10 between the first and second ends 12 and 14 and has a width W′ between the plane of the planar segments 32 and 34 and the plane containing the apex of base 44 as shown in Fig. 2. Arms 40 and 42 of constriction 26 are connected to the inner corners 36 and 38 at junctions, respectively. The constriction 26 has a height H′ defined by the perpendicular distance between the junctions as shown in Fig. 2. The building element 10 defines an interior cavity 45 that is open between the side flanges 18 and 20. The cavity 45 is capable of receiving or accommodating various structural members or construction components as explained further below.

(0054) The apex of base 44 is spaced from the plane of planar segments 32 and 34 about one-third the distance that the plane of tips 29 and 31 is spaced from the planar segments; and, accordingly, the width W′ of the constriction 26 is about one-third the overall width W of the building element. The width W′ of the constriction 26 may be about the same as or slightly greater than the height H′ of the constriction. The width W′ of the constriction 26 is no greater than one-fourth the overall height H of the

building element. In one preferred embodiment, the width W′ of the constriction 26 is about one-sixth the overall height H of the building element, and the overall width W of the building element is slightly less than one-half the overall height H. In a preferred embodiment, the constriction 26 has a height H′ no greater than one-fourth the overall height H, and preferably the height H′ of the constriction is about one-sixth the overall height H. The radius of curvature for outer corners 22 and 24 is less than the radius of curvature for inner corners 36 and 38. The radius of curvature for base 44 is less than the radius of curvature for outer corners 22 and 24. The constriction axis X for constriction 26 is centrally located along the overall height H but may be non-centrally located along the overall height as explained below for building element 1010. The web 16 may be formed with more than one constriction. Preferably, the building element 10 is formed by a cold folding process involving plastic deformation of a metal sheet. The building element 10 can be manufactured automatically using high capacity shaping rods.

(0055) The profile defined by building element 10 renders it greatly resistant to compression, traction and tension. The constriction 26 is optimal because its length-to-width ratio enables it to resist greater compression. The shape, location and proportions of the constriction provide considerable advantages in load capacity, stability and integrity. The building element 10 can be used individually as a beam or column and can be assembled or combined with other building elements according to the present invention to form various building element assemblies usable as beam and column assemblies as explained further below. The building element 10 and the

assemblies obtained therewith are lighter in weight than conventional building elements, typically between ten and thirty percent lighter. The building element 10 and the beam and/or column assemblies formed therewith comply with current anti-seismic and structural steel regulations. The moment of inertia characteristics of the building element 10 limits displacements caused by seismic loads.

(0056) Figs. 3A - 3C are representative of a procedure for forming building element 10 from a metal sheet 46. With reference to Fig. 3A, the metal sheet 46 is seen to have an overall height h and a uniform or substantially uniform thickness T. The metal sheet 46 can be of any suitable length between the first and second ends thereof. As shown in Fig. 3B, outer portions of the sheet 46 are bent or folded from a middle or central portion thereof in the same direction to form a C-shaped profile. The C-shaped profile defined by sheet 46 at this stage includes web 16 and side flanges 18 and 20 extending from web 16. The C-shaped profile has an overall width W corresponding to the overall width of the finally formed building element. The constriction 26 is formed in web 16 by bending or folding as represented in Fig. 3C. The building element 10 is thereby finally formed with the resulting E-shaped profile having the overall height H. Accordingly, the metal sheet 46 from which the building element 10 can be formed has an overall height h greater than the overall height H of the finally formed building element 10 to account for bending of the sheet to form side flanges 18 and 20 and bending of the web 16 to form constriction 26.

(0057) Figs. 4A and 4B are representative of a process for forming the building element 10 from a standard structural steel member 48. The structural steel member 48 has a C-shaped profile defining a web 16 and side flanges 18 and 20 extending from web 16. A representative structural steel member is an ASTM 46-79b Type C structural member. The structural steel member 48 has an initial overall height h′ greater than the overall height desired for the building element 10 to be formed therewith, an overall width W corresponding to the overall width desired for the building element 10 and a uniform or substantially uniform thickness T. Also, the structural steel member 48 has a length between first and second ends thereof corresponding to the length desired for the building element 10. In order to form the building element 10 from the structural steel member 48, the web 16 thereof is bent or folded to form constriction 26 therein as shown in Fig. 4B. The building element 10 is thusly formed having the E-shaped profile with an overall height H smaller than the initial height h′ of the structural steel member 48.

(0058) Fig. 5 illustrates use of building element 10 individually as a column and as a mechanical joint or connector for another structural member. When used as a column, the building element 10 typically extends vertically in the building or other structure in which it is installed, as represented in Fig. 5 by a sectional top view of the building element. Fig. 5 illustrates a wall structure 50, which also typically extends vertically, disposed in cavity 45 between the side flanges 18 and 20 of building element 10. The wall structure 50 has parallel outer faces 52a and 52b and a side or end face

54 extending between the outer faces 52a and 52b. The wall structure 50 is disposed between the side flanges 18 and 20 with the side or end face 54 located between constriction 26 and side edges 28 and 30, and with the side flanges 18 and 20 overlapping and abutting the outer faces 52a and 52b, respectively. In the arrangement illustrated in Fig. 5, the side face 54 is located approximately midway between the side edges 28 and 30 and the planar segments 32 and 34 such that the side face 54 is spaced a short distance from the base 44 of constriction 26 and, therefore, does not contact the constriction 26. It should be appreciated, however, that the side face 54 can be located various distances from the constriction 26 and can abut the constriction 26. The building element 10 can be secured to the wall structure 50 in various diverse ways depending on the construction and/or materials of the wall structure 50. For example, suitable fasteners (not shown) can be inserted through the side flanges 18 and 20, respectively, and into the wall structure 50. The building element 10 can be assembled to various types of wall structures 50 including conventional panel, brick or block wall structures. In addition to wall structures, the building element 10 can be used as a mechanical joint or connector for other types of structural members including floor structures, ceiling structures and windows, for example. Also, the cavity 45 can be used to accommodate various construction components such as electrical wiring and plumbing, for example. The building element 10 can also be used individually as a beam as described further below. The building element 10 can be used individually as a beam or column without a structural member or construction components received in the cavity.

(0059) Use of building element 10 individually as a beam and as a mechanical joint or connector for a floor structure is illustrated in Fig. 6. When used as a beam, the building element 10 typically extends horizontally in the building or other structure in which it is installed, as represented in Fig. 6 by a sectional end view of the building element. A floor structure 56, which also typically extends horizontally, is disposed in cavity 45 between the side flanges 18 and 20. The floor structure 56 has parallel outer faces 58a and 58b and a side or end face 60 extending between the outer faces 58a and 58b. The floor structure 56 is disposed between the side flanges 18 and 20 with the side flanges 18 and 20 overlapping and abutting the outer faces 58a and 58b, respectively, and with the side face 60 disposed about midway between planar segments 32 and 34 and side edges 28 and 30 such that the side face 60 is spaced from the constriction 26 a short distance. Of course, the distance between the side face 60 and the constriction 26 can vary, and the side face 60 can abut the constriction. The building element 10 can be connected or secured to the floor structure 56, such as via connectors or fasteners inserted through the side flanges 18 and 20 and into the floor structure 56. In a similar manner, the building element 10 can receive and be secured to a horizontally extending ceiling structure.

(0060) Fig. 7 illustrates two building elements 10a and 10b assembled in web-to-web relation to form a building element assembly 62 for use as a column or beam assembly. In the building element assembly 62, first and second building elements 10a and 10b, which are the same as building element 10, are assembled and secured in

position with their webs 16a and 16b in abutment and, in particular, with the planar segments of webs 16a and 16b in abutment. The planar segment 32a of the first building element 10a is in abutment with the planar segment 32b of the second building element 10b. The planar segment 34a of the first building element 10a is in abutment with the planar segment 34b of the second building element 10b. Accordingly, the side flanges 18a and 20a of the first building element 10a extend in a first direction, i.e. to the left, while the side flanges 18b and 20b of the second building element 10b extend in a second, opposite direction, i.e. to the right, looking at Fig. 7. The building element assembly 62 has an overall height corresponding to the overall height H of the first and second building elements 10a and 10b and an overall width corresponding to the combined overall widths W of the first and second building elements 10a and 10b. Accordingly, the overall height of the building element assembly 62 is equal to the overall height H of an individual building element 10a, 10b while the overall width of the building element assembly is equal to two times the overall width W of an individual building element 10a, 10b. The first and second building elements 10a and 10b can be secured in position in web-to-web relation in various ways including securement or attachment of the first and second building elements to one another, such as by welding.

(0061) When used as a column assembly, the building element assembly 62 will typically be oriented vertically in the building or other structure in which it is installed, in which case Fig. 7 may be considered a sectional top view. When used as a beam assembly, the building element assembly 62 will typically be oriented horizontally in the

building or other structure in which it is installed, in which case Fig. 7 may be considered a sectional end view. Of course, the building element assembly 62 can be used as a mechanical joint or connector for one or more structural members, such as wall, floor and ceiling structures as well as windows. For example, a first structural member can be disposed in the cavity of the first building element 10a between the side flanges 18a and 20a, and a second or another structural member can be disposed in the cavity of the second building element 10b between the side flanges 18b and 20b. Accordingly, one or more structural members can be assembled to and connected with the building element assembly 62 in a manner similar to that described above.

(0062) Fig. 8 illustrates assembly of the first and second building elements 10a and 10b in tip-to-tip relation to form an alternative building element assembly 64. In building element assembly 64, the first building element 10a has its tip 29a in abutment with the tip 29b of the second building element 10b via abutment of side edges 28a and 28b. The first building element 10a has its second tip 31a in abutment with the tip 31b of the second building element 10b via abutment of side edges 30a and 30b. The side flanges 18a and 20a of the first building element 10a extend from its web toward the right, and the side flanges 18b and 20b of the second building element 10b extend from its web toward the left looking at Fig. 8. The overall height and the overall width for the building element assembly 64 are the same as those for building element assembly 62. The first and second building elements can be secured in position in tip-to-tip relation in various ways including securement or attachment of the first and second building elements to one another, such as by welding along the abutting tips or side edges.

(0063) The building element assembly 64 can be used as a column assembly or as a beam assembly. When used as a column assembly, the building element assembly 64 will typically be oriented vertically in the building or other structure in which it is installed. When used as a beam assembly, building element assembly 64 will typically be oriented horizontally in the building or other structure in which it is installed. In the building element assembly 64, the first and second building elements enclose or circumscribe an interior space 65, which can be used to receive or accommodate various construction components such as electrical wiring and/or plumbing.

(0064) Another building element assembly 66 is illustrated in Fig. 9 and comprises first, second and third building elements 10a, 10b and 10c assembled together, the building elements 10a, 10b and 10c each being the same as building element 10. In the building element assembly 66, the first and second building elements 10a and 10b are assembled in web-to-web relation as described for building element assembly 62. Accordingly, the planar segments 32a and 34a of the web 16a of the first building element 10a are in abutment with the planar segments 32b and 34b, respectively, of the web 16b of the second building element 10b. The third building element 10c is assembled to the first and second building elements 10a and 10b in web-to-side relation, with the web 16c of the third building element 10c in abutment with the side flanges 18a and 18b of the first and second building elements 10a and 10b, respectively. In particular, the planar segment 32c of the web 16c is in abutment with the side flange 18a of the first building element 10a, and the planar segment 34c of the

web 16c is in abutment with the side flange 18b of the second building element 10b. The third building element can be secured in position in web-to-side relation with the first and second building elements in various ways including securement or attachment of the third building element to the first and second building elements such as by welding. The third building element 10c has an overall height H the same as or substantially the same as the combined widths W of the first and second building elements 10a and 10b. The building element assembly 66 has an overall width corresponding to the combined widths W of the first and second building elements 10a and 10b and also corresponding to the height H of the third building element 10c. The building element assembly 66 has an overall height corresponding to the overall height H of the first and second building elements 10a and 10b plus the overall width W of the third building element 10c.

(0065) The building element assembly 66 can be used as a beam assembly, typically oriented horizontally in the building or other structure in which it is installed, or a column assembly, typically oriented vertically in the building or other structure in which it is installed. In addition, the building element assembly 66 can be used as a mechanical joint or connector for one or more structural members, such as wall structures, floor structures, ceiling structures and/or windows. For example, a first structural member can be disposed between the side flanges of the first building element 10a, a second structural member can be disposed between the side flanges of the second building element 10b and/or a third structural member can be disposed between the side flanges of the third building element 10c. Of course, the cavities

defined by the individual building elements can remain vacant or can be used to accommodate various construction components such as electrical wiring and/or plumbing.

(0066) Fig. 10 depicts a building element assembly 68 formed by four building elements, i.e. first building element 10a, second building element 10b, third building element 10c and fourth building element 10d, all of which are similar to building element 10. The first, second and third building elements 10a, 10b and 10c are assembled as described for building element assembly 66 so that the planar segments 32c and 34c of the third building element 10c are in abutment with the side flanges 18a and 18b of the first and second building elements 10a and 10b, respectively. The fourth building element 10d can be secured in position with the first, second and third building elements 10a, 10b, 10c in various ways including securement or attachment of the fourth building element to the first and second building elements such as by welding. The fourth building element 10d is assembled to the first and second building elements 10a and 10b with the planar segments 32d and 34d of its web 16d in abutment with the side flanges 20a and 20b of the first and second building elements 10a and 10b, respectively. The fourth building element 10d has an overall height the same as or substantially the same as the overall height H of the third building element 10c, and the building element assembly 68 has an overall width corresponding to the overall height H of the third building element 10c, which corresponds to the combined overall widths of the first and second building elements 10a, 10b. The building element assembly 68 has an overall height corresponding to the overall height H of the first and second

building elements 10a and 10b plus the overall widths W of the third and fourth building elements 10c and 10d. The building element assembly 68 can be used as a column assembly or as a beam assembly as discussed above. One or more of the cavities of the four building elements forming the building element assembly 68 can be used to receive or accommodate a structural member, such as a wall structure, floor structure, ceiling structure or a window, and/or various construction components such as wiring and/or plumbing. Accordingly, the building element assembly 68 can serve as a mechanical joint or connector for one or a plurality of structural members.

(0067) Another building element assembly 70 made up of four building elements 10a, 10b, 10c and 10d, which are each similar to building element 10, is illustrated in Fig. 11. Building element assembly 70 has first and second building elements 10a and 10b assembled together in web-to-web relation with the planar segments 32a and 34a of the first building element 10a in abutment with the planar segments 32b and 34b of the second building element 10b, respectively, as described for building element assembly 62. The third and fourth building elements 10c and 10d of building element assembly 70 are assembled together in web-to-web relation in the same manner as the first and second building elements thereof. Accordingly, planar segments 32c and 34c of the third building element 10c are in abutment with the planar segments 32d and 34d of the fourth building element 10d, respectively. The first and second building elements 10a and 10b are assembled to the third and fourth building elements 10c and 10d in side-to-side relation, with the side flange 20a of the first building element 10a in abutment with the side flange 18c of the third building element 10c and the side flange

20b of the second building element 10b in abutment with the side flange 18d of the fourth building element 10d. The first and second building elements 10a, 10b can be secured in position with the third and fourth building elements 10c, 10d in various ways including securement or attachment of the first and second building elements to the third and fourth building elements such as by welding. The building element assembly 70 has an overall width corresponding to the combined overall widths W of the first and second building elements 10a and 10b, which is the same as or substantially the same as the combined overall widths of the third and fourth building elements 10c and 10d. The building element assembly 70 has an overall height corresponding to the overall height H of the first and second building elements 10a and 10b plus the overall height H of the third and fourth building elements 10c and 10d. The building element assembly 70 can be used as a beam assembly or as a column assembly as explained above. One or more of the cavities of the four building elements making up the building element assembly 70 can be used to receive or accommodate structural members and/or various construction components as discussed above.

(0068) Fig. 12 illustrates a building element assembly 72 made up of four, five or six building elements. Building element assembly 72 includes first and second building elements 10a and 10b, similar to building element 10, assembled together in web-to-web relation, and second and third building elements 10c and 10d, similar to building element 10, also assembled in web-to-web relation as described for building element assembly 62. Accordingly, the planar segments 32a and 34a of the first building element 10a are in abutment with the planar segments 32b and 34b of the second

building element 10b, respectively, and the planar segments 32c and 34c of the third building element 10c are in abutment with the planar segments 32d and 34d of the fourth building element 10d, respectively. The third and fourth building elements 10c and 10d are assembled to the first and second building elements 10a and 10b with the second building element 10b in tip-to-tip relation with the third building element 10c. Accordingly, the side edges 28b and 30b of the second building element 10b are in abutment with the side edges 28c and 30c of the third building element 10c, respectively. The third and fourth building elements 10c, 10d can be secured in position with the first and second building elements 10a, 10b in various ways including securement or attachment of the second building element to the third building element such as by welding along their tips or side edges 28b, 30b, 28c and 30c. The first, second, third and fourth building elements 10a, 10b, 10c and 10d have an overall height H. The first, second, third and fourth building elements 10a, 10b 10c and 10d each have an overall width W.

(0069) A fifth building element 10e, shown in dotted lines, may be assembled in web-to-side relation with the second and third building elements 10b, 10c with the planar segment 32e of the fifth building element 10e in abutment with the side flange 18b of the second building element 10b and the planar segment 34e of the fifth building element 10e in abutment with the side flange 18c of the third building element 10c. The fifth building element can be secured in position with the second and third building elements in various ways including securement or attachment of the fifth building element to the second and third building elements such as by welding. The fifth building

element 10e has an overall height the same as or substantially the same as the combined widths W of the second and third building elements 10b and 10c and an overall width W the same as or substantially the same as the overall width W of the first, second, third and fourth building elements.

(0070) A sixth building element 10f, shown in dotted lines, may be assembled in web-to-side relation with the second and third building elements 10b and 10c, with the planar segment 32f of the sixth building element 10f in abutment with the side flange 20b of the second building element 10b and the planar segment 34f of the sixth building element 10f in abutment with the side flange 20c of the third building element 10c. The sixth building element can be secured in position with the second and third building elements in various ways including securement or attachment of the sixth building element to the second and third building elements such as by welding. The sixth building element 10f has an overall height the same as or substantially the same as the combined widths W of the second and third building elements 10b and 10c and an overall width W the same as or substantially the same as the overall width W of the first, second, third and fourth building elements.

(0071) Where the building element assembly 72 is formed of the first, second, third and fourth building elements 10a, 10b, 10c and 10d, it has an overall height corresponding to the overall height H of the first, second, third and fourth building elements and an overall width corresponding to the combined widths, i.e. 4 x W, of the

first, second, third and fourth building elements. Where the building element assembly 72 is made up of the first, second, third, fourth and fifth building elements 10a, 10b, 10c, 10d and 10e, it has an overall height corresponding to the overall height H of the first, second, third and fourth building elements 10a, 10b, 10c and 10d plus the overall width W of the fifth building element 10e. Where the building element assembly 72 is made up of the first, second, third, fourth and fifth building elements, it has an overall width corresponding to the combined overall widths W of the first, second, third and fourth building elements. Where the building element assembly 70 is made up of six building elements 10a, 10b, 10c, 10d, 10e and 10f, it has an overall height corresponding to the overall height H of the first, second, third and fourth building elements 10a, 10b, 10c and 10d plus the combined overall widths W of the fifth and sixth building elements 10e and 10f and has an overall width corresponding to the combined widths, i.e. 4 x W, of the first, second, third and fourth building elements. The space 65 circumscribed by the second and third building elements 10b and 10c can be used to receive or accommodate various building components. The cavities of the first and fourth building elements and the cavities of the fifth and sixth building elements, where provided, can be used to receive or accommodate various building components and/or can be used as mechanical joints or connectors for various structural members. The building element assembly 72 can be used as a beam assembly or as a column assembly as explained above.

(0072) An alternative building element according to the present invention is illustrated at 110 in Fig. 13. The building element 110 is similar to building element 10

except that two constrictions 126a and 126b are formed in web 116 of building element 110. Building element 110 has first constriction 126a disposed midway between side flange 118 and the central axis X′ bisecting the web 116 along its height, and second constriction 126b disposed midway between side flange 120 and the central axis X′. Web 116 includes a planar segment 132 between constrictions 126a and 126b. The arms of constriction 126a, which is similar to constriction 26, are connected to inner corners 136a and 138a, respectively. Inner corner 136a is connected to outer corner 122, and inner corner 138a is connected to planar segment 132. Constriction 126b is similar to constriction 126a, with the arms of constriction 126b joined to inner corners 136b and 138b, respectively. Inner corner 136b is connected to planar segment 132, and inner corner 138b is connected to outer corner 124. The apex and constriction axis of constriction 126a are located midway between the side flange 118 and the central axis X′. The apex and constriction axis of constriction 126b are located midway between the side flange 120 and the central axis X′. A center of the planar segment 132 is coincident with the central axis X′. The inner corners 136a and 138b are connected to the outer corners 122 and 124, respectively, at junctions disposed in the same plane as planar segment 132. Depending on the height of the building element, these junctions may be planar segments of web 116 disposed between the inner corners 136a and 138b and the outer corners 122 and 124, respectively. In other respects, the building element 110 is similar to building element 10. The building element 110 can be used individually as a beam or a column, or in combination with one or more other building elements in a building element assembly useable as a beam assembly or a column assembly as described above.

(0073) Fig. 14 illustrates another building element 210 similar to the building element 110 except that the building element 210 has three constrictions 226a, 226b and 226c formed in the web 216. Constrictions 226a, 226b and 226c are similar to constriction 26, with the apex and constriction axis of constriction 226b being centrally located between side flanges 218 and 220 and being coincident with the central axis of building element 210. Constriction 226a has its apex and constriction axis located midway between the central axis and the side flange 218. Constriction 226c has its apex and constriction axis located midway between the central axis and the side flange 220. First constriction 226a has its arms joined to inner corners 236a and 238a, respectively. Second constriction 226b has its arms joined to inner corners 236b and 238b, respectively. Third constriction 226c has its arms joined to inner corners 236c and 238c, respectively. The inner corner 236a is joined to the outer corner 222, and the inner corner 238a is joined to the inner corner 236b. The inner corner 238b is joined to the inner corner 236c. The inner corner 238c is joined to the outer corner 224, such that the web 216 does not have any planar segments. The inner corners 236a and 238c are joined to the outer corners 222 and 224, respectively, at junctions disposed in the same plane as the junctions defined where the inner corners 238a and 238b are joined to the inner corners 236b and 236c, respectively. In other respects, the building element 210 is similar to the building element 110. The web 216 may be configured with planar segments between the constrictions 226a and 226b and between the constrictions 226b and 226c and/or with planar segments between the inner corners 236a, 238c and the outer corners 222, 224, respectively. The building element 210 can be used individually as a beam or column, or in combination with one

or more other building elements to form a building element assembly usable as a beam assembly or a column assembly.

(0074) Another building element 310 is illustrated in Fig. 15 and is similar to building element 210 except that the building element 310 has four constrictions 326a, 326b, 326c and 326d in web 316. Constrictions 326a and 326b are disposed on one side of the central axis for building element 310, and the constrictions 326c and 326d are disposed on the opposite side of the central axis. The junction at which the inner corners 338b and 336c are joined is coincident with the central axis. Each constriction 326a, 326b, 326c and 326d has an apex and a constriction axis, the apexes being spaced from one another about the same distance along the overall height of the building element. The web 316 could be configured with planar segments between the constrictions 326a and 326b, between the constrictions 326b and 326c, and between the constrictions 326b and 326d. The web 316 could be configured with planar segments between the constrictions 326a, 326d and the outside corners 322, 324, respectively.

(0075) Another alternative building element is illustrated in Fig. 16 at 410. The building element 410 is similar to building element 10 except that side flanges 418 and 420 of building element 410 have outwardly extending protrusions 474a and 474b, respectively. Each protrusion is rounded, arcuate or curved having a convex, dome-shape or hemisphere configuration extending outwardly from the corresponding side

flange in a direction away from the cavity 445 defined by the building element 410. The protrusions 474a and 474b extend the entire length of the building element 410 in a direction parallel to the plane containing the planar segments 432 and 434. Each protrusion 474a and 474b has an apex located a maximum distance outwardly of the corresponding side flange, and the apex of each protrusion is located about midway along the corresponding side flange. Accordingly, each protrusion 474a and 474b is disposed between planar portions of the corresponding side flange, and such planar portions are of the same or substantially the same width on opposite sides of the protrusion. The protrusions 474a and 474b can be formed in a manner similar to that described above for formation of the constrictions. The building element 410 can be made by forming or bending a metal sheet or by forming or bending a standard structural steel member as described above. The protrusions 474a and 474b provide increased load capacity for the building element 410, which can be used individually as a beam or a column or in combination with one or more other building elements in a building element assembly useable as beam or column assemblies as described above.

(0076) Fig. 17 illustrates another building element 510, which is similar to building element 410 except that the building element 510 has inwardly extending protrusions 574a and 574b in the side flanges 518 and 520 thereof. Protrusions 574a and 574b are similar to protrusions 474a and 474b except that the protrusions 574a and 574b extend or protrude inwardly into or toward the cavity 545 defined by the building element 510. Accordingly, the protrusions 574a and 574b have a concave

configuration or profile. Each protrusion 574a and 574b has an apex located a maximum distance inwardly of the corresponding side flange, and the apex of each protrusion is located about midway along the corresponding side flange. The protrusions 574a and 574b impart increased load capacity to the building element 510, which can be used individually as a beam or a column or in combination with one or more other building elements in a building element assembly useable as a beam assembly or a column assembly.

(0077) Another building element is illustrated in Fig. 18 at 610 and is similar to building element 10 except that the tips 629 and 631 of the side flanges 618 and 620 of building element 610 are inwardly curved or angled. The tips 629 and 631 of the side flanges 618 and 620, respectively, of the building element 610 comprise end flanges that curve or angle inwardly toward one another with the same or substantially the same radius of curvature as the outer corners 622 and 624, respectively. The curved tips 629 and 631 extend from the planar portions of the side flanges 618 and 620, respectively, and are about the same length as the outer corners 622 and 624, respectively, such that each tip 629, 631 forms an angle with the planar portion of the corresponding side flange 618, 620 that is less than 90 ° and may be about 45 degrees. In the case of building element 610, the overall width of the building element is defined between the plane of the planar segments 632, 634 of the web 616 and the plane of the tips 629, 631. The plane of the tips 629, 631 is a plane that abuts both tips 629, 631 and is also maximally spaced from and parallel to the plane of the planar segments 632, 634. The end flanges defined by the inwardly curved tips 629 and 631

may be of any suitable length and provide a mechanical joint or connector facilitating assembly of a pair of the building elements 610 in tip-to-tip relation as explained further below.

(0078) Fig. 19 illustrates another building element 710 that is similar to building element 610 except that the tips 729 and 731 of building element 710 curve outwardly. The tips 729 and 731 comprise end flanges that curve outwardly from planar portions of side flanges 718 and 720, respectively, in a direction away from one another and have a radius of curvature that is the same as or substantially the same as the radius of curvature of outer corners 722 and 724, respectively. However, the direction of curvature of tips 729 and 731 is reverse to that of outer corners 722 and 724, respectively. The tips 729 and 731 have a length about the same as the length of outer corners 722 and 724, respectively, and each tip 729, 731 forms an angle with the planar portion of the corresponding side flange 618, 620 that is less than 90 degrees and may be about 45 degrees. The end flanges defined by the tips 729 and 731 may be of any suitable length. The plane of tips 729, 731 from which the overall width of the building element 710 is defined is a plane that abuts both tips 729, 731 and is also maximally spaced from and parallel to the plane of the planar segments 732, 734 of the web 716. The tips 729 and 731 provide a mechanical joint or connector facilitating assembly of a pair of building elements 710 in tip-to-tip relation. Also, when a pair of building elements 710 are assembled in web-to-web relation to form a building element assembly, the tips 729 of the building elements cooperate to form a first mechanical joint or connector for another structural member, and the tips 731 of the building

elements cooperate to form a second mechanical joint or connector for another structural member as explained further below.

(0079) Fig. 20 illustrates a building element assembly 76 formed by first and second building elements 610a and 610b, which are the same as building element 610, assembled in tip-to-tip relation. The inwardly angled tips or end flanges 629a and 631a of the first building element 610a are in abutment with the inwardly angled tips or end flanges 629b and 631b, respectively, of the second building element 610b. Abutment of the building elements 610a and 610b along their tips facilitates connection or attachment of the building elements 610a and 610b to one another, such as by welding along the abutting tips. The building element assembly 76 can be used as a beam assembly or as a column assembly as explained above. The building element assembly 76 defines an interior space 665 which may accommodate various construction components as explained above.

(0080) Fig. 21 illustrates a building element assembly 78 used as a column assembly and formed of first and second building elements 710a and 710b, which are the same as building element 710, assembled in web-to-web relation. Also, the building element assembly 78 is shown used as a connector for four structural members. A first wall structure 50a is disposed in the cavity defined by first building element 710a between the side flanges 718a and 720a. A second wall structure 50b is disposed in the cavity defined by second building element 710b between side flanges 718b and

720b. The tips 729a and 729b form a mechanical joint or connector for a third structural member, and the tips 731a and 731b form a mechanical joint or connector for a fourth structural member. In particular, a third wall structure 50c is disposed between the tips 729a and 729b with an end surface of the third wall structure 50c in abutment with the side flanges 718a and 718b. A fourth wall structure 50d is disposed between the tips 731a and 731b with an end surface of the fourth wall structure 50d in abutment with the side flanges 720a and 720b.

(0081) Fig. 22 illustrates a further building element 810 and also illustrates a building element assembly 80 formed by a pair of building elements 810 assembled to one another in tip-to-tip relation. The building element 810 has protrusions 874a and 874b and is similar to the building element 410 except that the building element 810 has inwardly angled tips 829 and 831. The tips 829 and 831 are the same as the tips 629 and 631, respectively. When the building elements 810 are assembled in tip-to-tip relation, the tips 829 and 831 of one building element 810 are in abutment with the tips 829 and 831 of the other building element 810. Building element assembly 80 can be used as a beam assembly or a column assembly. However, it should be appreciated that the building element 810 can be used individually as a beam or as a column as described above.

(0082) Another building element according to the present invention is illustrated at 910 in Fig. 23, which also illustrates a building element assembly 82 obtained when

two building elements 910, i.e. first building element 910a and second building element 910b are assembled in web-to-web relation. The building element 910, as described in connection with first building element 910a, is similar to building element 610 but has tips 929 and 931 inwardly angled 90 degrees to the planar portions of the side flanges 918 and 920, respectively. The building element 910 can have one or more constrictions 926, similar to constriction 26, along its web 916. The building element 910 is depicted with a central constriction 926 along its web 916 as described for building element 10. The arms 940 and 942 of the constriction 926 each define an angle of or about 35 degrees with the constriction axis X that bisects the base 944 at its apex, such that the arms 940 and 942 define an included angle A of or about 70 degrees. In the case of a centrally located constriction 926 as illustrated for building element 910, the constriction axis X is also the central axis of the building element centrally located between the side flanges 918 and 920. The arms 940, 942 of the constriction 926 are straight or linear between base 944 and inner corners 936, 938, respectively. The tips 929 and 931 are joined to the planar portions of the side flanges 918 and 920, respectively, by outside corners 923 and 925, respectively, having the same radius of curvature as the outer corners 922 and 924. The tips 929 and 931 comprise respective end flanges extending linearly from the outside corners 923 and 925 to the edges 928 and 930, respectively. The tips 929 and 931 are coplanar and parallel to the plane of planar segments 932, 934. The end flanges defined by tips 929 and 931 are at a 90° angle to the planar portions of the side flanges 918 and 920 but could be at an angle less than 90° to the planar portions of the side flanges. The end flanges defined by tips 929 and 931 extend inwardly, however, the end flanges defined

by tips 929 and 931 could extend outwardly. The end flanges can be linear or curved and may be of any suitable length. The side flanges 918 and 920 may have inward and/or outward protrusions as described above.

(0083) The building element 910 has an overall height H and an overall width W. The height H is defined between parallel planes containing outer surfaces of the planar portions of side flanges 918 and 920, respectively. The overall width W is defined between the plane containing the outer faces or surfaces of both planar segments 932 and 934 and the parallel plane containing the outer faces or surfaces of both tips 929 and 931. Preferably, the width W is one half the height H. The width W′ of the constriction 926 is about one-third the overall width W of the building element 910. The height H′ of the constriction is no greater than one-fourth the overall height H of the building element and may be about one-sixth the overall height H of the building element. In one preferred embodiment, the height H′ of the constriction 926 is about 4.2 cm.

(0084) When the building elements 910a and 910b are assembled in web-to-web relation to form building element assembly 82, the planar segments 932 and 934 of building element 910a are respectively in abutment with the planar segments of building element 910b. The building element assembly 82 has an overall height equal to the height H of an individual building element 910a, 910b and an overall width equal to the combined widths of the building elements 910a and 910b, i.e. two times W. Since the width W is one-half the height H, the overall height H of the building element assembly

82 will be equal to its overall width. The building element assembly 82 is particular useful as a column assembly.

(0085) An additional building element 1010 according to the present invention is depicted in Fig. 24, which also illustrates a building element assembly 84 formed by two building elements 1010, i.e. first building element 1010a and second building element 1010b, assembled in web-to-web relation. The building element 1010 is similar to building element 910 but has a constriction 1026 non-centrally located between the side flanges 1018 and 1020 along the height of the building element. Also, the overall height H of the building element 1010 is about four times its overall width W. The building element 1010, as described in connection with building element 1010a, has constriction 1026 located along the overall height H of the building element 1010 such that the constriction axis X is located a distance of or about two-thirds the overall height H from the plane containing the outer surface or face of side flange 1018 and a distance of or about one-third the overall height H from the plane containing the outer face or surface of the other side flange 1020. The constriction 1026 is similar to constriction 926 and has linear arms 1040 and 1042 extending from base 1044 to inner corners 1036 and 1038, respectively. The arms 1040 and 1042 define an included angle of or about 70 degrees bisected by the constriction axis X. The tips 1029 and 1031 of building element 1010 are similar to tips 929 and 931. Accordingly, the tips 1029 and 1031 are coplanar and parallel to the plane of planar segments 1032, 1034. The tips 1029 and 1031 are joined to the planar portions of the side flanges 1018 and 1020, respectively, by outside corners 1023 and 1025, respectively, having the same

radius of curvature as the outer corners 1022 and 1024 as explained for building element 910. The tips 1029 and 1031 are linear from the outside corners 1023 and 1025 to the edges 1028 and 1030, respectively and thusly do not comprise end flanges. However, the tips 1029 and 1031 may comprise any of the end flanges described above. The side flanges 1018 and 1020 may have inward and/or outward protrusions.

(0086) The overall height H of building element 1010 is defined between the parallel planes containing the outer surfaces of the planar portions of side flanges 1018 and 1020. The overall width W of building element 1010 is defined between the plane containing the outer faces or surfaces of both planar segments 1032 and 1034 and the parallel plane containing the outer faces or surfaces of both tips 1029 and 1031. The height H is about four times the width W so that the width W is conversely about one-fourth the height H. The width W′ of the constriction 1026 is about one-third the overall width W of the building element 1010. The height H′ of the constriction 1026 is no greater than one-fourth the overall height H of the building element 1010. In one preferred embodiment, the height H′ of the constriction 1026 is about 4.2 cm.

(0087) When the building elements 1010a and 1010b are assembled in web-to-web relation to form building element assembly 84, the planar segments 1032 and 1034 of building element 1010a are in abutment with the planar segments, respectively, of building element 1010b. The building element assembly 84 has an overall height equal to the overall height H of an individual building element 1010a, 1010b and has an

overall width equal to the combined widths W of the building elements 1010a and 1010b, i.e. two times W. Since the width W is one-fourth the height H, the overall height H of the building element assembly 84 will be twice its overall width. Conversely, the overall width of the building element assembly 84 will be one-half its overall height H. The building element assembly 84 is particularly useful as a beam assembly with the constriction 1026 optimally located from a bottom side flange 1020 of the building element 910 to sustain tensile loads.

(0088) The building elements according to the present invention have been found through testing to exhibit increased strength in tension (traction), compression and torsion (flexion). For example, a building element 10 having a thickness or caliber of 2mm was tested in tension and found to have a break load of 2210 kg, a maximum load of 3200 kg, 30.9% elongation, 46.6% narrowing and an ultimate effort to break of 2954 kg/cm^2. When tested in compression, a building element 10 having a thickness of 2mm was found to have a maximum load of 55,000 kg, a slenderness ratio of 7.08 and a crushing percentage of 3.5%. When tested in torsion in the x-x direction, a building element 10 having a thickness of 2mm had a maximum horizontal shear of 171.57 kg/cm^2, a maximum vertical shear of 171.57 kg/cm^2, a maximum concentrated load of 6000 kg and a maximum deformation of 0.510mm. From testing performed on various sizes of building elements according to the present invention, it has been found that the building elements of the present invention are as strong as building elements of 30 to 40% more weight. Accordingly, the building elements of the present invention require less weight and, therefore, material, to obtain a desirable strength in tension,

compression and/or torsion.

(0089) The building elements according to the present invention display enhanced load capacity and resist higher compression and tension forces. The building elements have increased rigidity and stability. The building elements can be formed by bending or shaping metal sheets or pre-formed standard structural members. The building elements can be used individually as beams or columns or can be combined with one or more other building elements to form building element assemblies useable as beam assemblies or column assemblies. Any number of building elements can be combined in a building element assembly. Building elements of different types can be combined in a building element assembly. A single building element can have any number of constrictions, outward protrusions and/or inward protrusions. The tips of the side flanges may comprise end flanges angled inwardly or outwardly, and the angle of the end flanges with the side flanges may vary. The length of the end flanges may also vary, and the end flanges may be linear or curved. The constrictions can be located at various locations along the height of the building elements, and may be optimally located from a bottom side flange of the building element for use as a beam. A building element assembly can be formed by combining similar and/or dissimilar building elements. The building elements can be assembled in various ways including web-to-web, tip-to-tip and web-to-side arrangements. The building elements of a building element assembly can be secured in position in various ways including attachment of the building elements to one another and/or securement or attachment of the building elements to other structural elements used in the building

or other structure in which the building element assembly is installed. Each building element defines a cavity capable of receiving construction components and/or one or more structural members to be connected to the building element. The building elements can be assembled to define or enclose an interior space capable of receiving construction components such as electrical wiring and/or plumbing. The tips of the building elements can be shaped to provide a mechanical joint or connector facilitating connection of the building elements to one another and/or to various structural members. The mechanical joints or connectors provided by the building elements for structural members, such as wall structures, floor structures, ceiling structures and/or windows, permit elimination of the cracks that normally appear when different materials are joined. The building elements find particular application in construction, expansion and renovation of homes and other buildings. The building elements can be easily placed or installed where needed. The building elements are reasonably priced, minimize waste and reduce construction costs.

(0090) It should be appreciated that the present invention is subject to various modifications, variations and changes in detail. Accordingly, the foregoing description of the preferred embodiments should be considered illustrative only and should not be taken in a limiting sense.